Characterizing Biological Closed-Loop Life Support Systems for Thermal Control and Revitalization of Spacecraft Cabin Environments

Completed Technology Project (2015 - 2019)

Project Introduction

Environmental Control and Support Systems (ECLSS) are required for all manned spaceflight missions to provide the most fundamental physiological needs. One of these needs is the ability to remove carbon dioxide (CO2) and supply oxygen (O2) into the cabin atmosphere. NASA's current technology, designated to sequester CO2 and resupply O2, will not be able to support NASA's Strategic Plan for long duration spaceflight due to its inability to recover enough O2 and concerns from NASA about its open loop design. Instead, terrestrial designs have shown photosynthetic-based systems can provide a relatively reliable, closed loop solution for CO2 removal and O2 resupply. I look to benefit life in space with my research in algal photobioreactor technologies to provide the fundamental needs for biological existence. The research could be used to refine photobioreactors on Earth to make them more efficient and to provide a better understanding of the capabilities of the system. Furthermore, if my research demonstrates the ability to use an algal photobioreactor as a closed system in the spacecraft environment, the technology will enable humans to travel further into space. My research proposes to determine the feasibility of using an algal system to stabilize spacecraft cabin thermal environments while removing cabin CO2 and regenerating O2. A bench-top experiment, with algae Chlorella to characterize the feasibility, will employ resistive heating to imitate metabolic and hardware heating in the cabin, and a gas stream through the bag with a composition replicating the atmosphere from the cabin. My research plans to support this objective include: -Creating a detailed model of the algal and cabin system using a literature study to assign rates to inputs and outputs of the system, to fully characterize the system -Investigating the reliability of the algal system in space by using failure modes of terrestrial systems and applying spaceflight considerations -Experimentally quantifying the consequences that time-varying inputs will have on the algal system's CO2 turnover rates. The inputs to be varied are CO2, temperature, lighting, and N2 for growth-medium pH modification. Microgravity effects will also be assessed by use of a clinostat. With the completion of this research, I expect to know the viability of using an algal photobioreactor not only for cabin CO2 reduction and O2 regeneration, but also for controlling the spacecraft cabin thermal environment. Being able to control both atmospheric revitalization and thermal stability with one system will increase system functionality and reliability, making long duration spaceflight feasible.

Anticipated Benefits

The research could be used to refine photobioreactors on Earth to make them more efficient and to provide a better understanding of the capabilities of the system. Furthermore, if my research demonstrates the ability to use an algal photobioreactor as a closed system in the spacecraft environment, the technology will enable humans to travel further into space.

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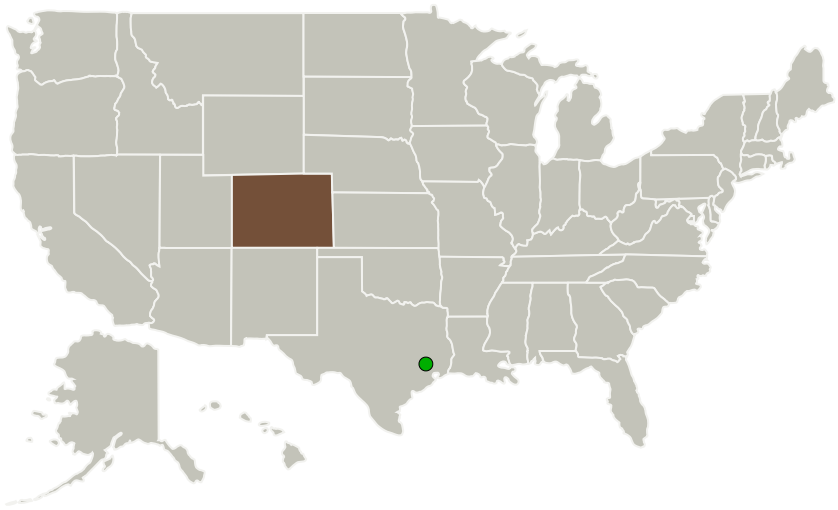
Primary U.S. Work Locations and Key Partners



Organizations Performing Work	Role	Type	Location
University of Colorado Boulder	Lead Organization	Academia	Boulder, Colorado
Johnson Space Center(JSC)	Supporting Organization	NASA Center	Houston, Texas

Primary U.S. Work Locations
Colorado

Project Website:

https://www.nasa.gov/strg#.VQb6T0jJzyE

Organizational Responsibility

Responsible Mission Directorate:

Space Technology Mission Directorate (STMD)

Lead Organization:

University of Colorado Boulder

Responsible Program:

Space Technology Research Grants

Project Management

Program Director:

Claudia M Meyer

Program Manager:

Hung D Nguyen

Principal Investigator:

James Nabity

Co-Investigator:

Emily E Matula

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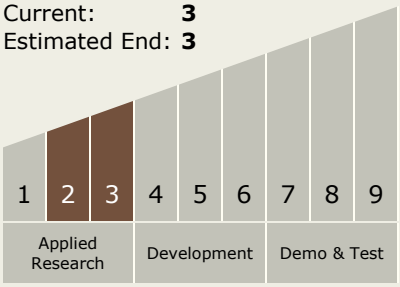
Completed Technology Project (2015 - 2019)

Technology Maturity (TRL)

Start: **2**
Current: **3**
Estimated End: **3**



Technology Areas

Primary:

- TX06 Human Health, Life Support, and Habitation Systems
  - TX06.1 Environmental Control & Life Support Systems (ECLSS) and Habitation Systems
    - TX06.1.5 ECLSS Modeling and Simulation Tools

Target Destinations

Earth, The Moon